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WORLD RESERVES AND RESOURCES OF TIN

BY

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By Charles White Merrill[2]

INTRODUCTION

Tin has become more and more indispensable to American industry in recent years. The canning and automobile industries, the outstanding consumers of tin and its alloys, have grown so great that over 40 per cent of the world's virgin tin production is consumed in the United States. Over 99 per cent of the virgin tin we require is imported from foreign sources. Domestic production of virgin tin has always been so small as to be negligible, and long-continued search has failed to reveal tin resources which will be available in the future at present or considerably higher prices. Only by the recovery of tin from scrap has the United States succeeded in supplying any appreciable portion of its requirements.

It is apparently inevitable that the United States will remain dependent upon foreign production for its future supply of virgin tin. For this reason the tin resources[3] of the world, including the tin reserves of producing companies, are of very vital interest to American tin consumers. Upon knowledge of resources and reserves must depend the stabilizing of metal prices. Recently the price of tin has fluctuated from a high of 72.50 cents in 1926 to a low of 38.37 cents in 1929. The former excessive price was made possible by the fear of shortage on the part of American consumers.

Though it is thus obvious that estimates of future trends of production and price must be based upon knowledge of world resources and reserves, precise data for compilation of world totals are not available. The Chinese placer miners of Malaya who own large tin-bearing tracts do not find it necessary to measure their reserves; the Dutch Government refuses to disclose the reserves of the Banka placers; and the lode mines, from which one-third of the world production is derived, do not generally attempt any extensive development of reserves beyond their relatively immediate requirements.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6249."

[2] - Mining engineer, common metals division, U. S. Bureau of Mines.

[3] - In studies of the common metals division of the Bureau of Mines the following distinction is made: Reserves include merchantable ore actually demonstrated by exposure and precise measurement. Resources include reserves as defined plus expectancies of ore based upon geological evidence or upon the possibility of future utilization of mineralized material not workable as ores at present prices.

Nevertheless, it has been deemed probable that the tin-consuming industries of the United States would welcome an attempt to make such compilations of reserves as the available data permit and to indicate as far as possible the nature of unmeasured or unrevealed reserves.

PUBLISHED RESERVES

Published data give the reserves covering only one-fourth of the world production. These reserves are shown in the following table.

TABLE OF PRODUCTION AND RESERVES OF THE PRINCIPAL TIN-MINING COUNTRIES OF THE WORLD

Country	Total production in 1928, long tons	Production from companies reporting reserves				Reserves as reported by producing companies		Life based on reserves and 1928 production		Reserves reported by nonproducers	
		Placer, long tons	Lode, long tons	Total, long tons	Per cent of total production	Placer, long tons	Lode, long tons	Placer, years	Lode, years	Placer, long tons	Lode, long tons
Australia	2,900	211	-	211	7	2,639	-	12½	-	3,764	7,000
Belgian Congo	1,200	-	-	-	-	-	-	-	-	-	-
Bolivia	[1]41,409	-	23,548	23,548	57	-	130,000	-	5½	-	-
China	[1]7,033	-	-	-	-	-	-	-	-	-	-
United Kingdom	2,782	-	595	595	21	-	1,939	-	3	-	1,050
India	2,200	1,048	-	1,048	48	12,967	-	16½	-	8,192	-
Japan	(2)	-	148	148	-	-	3,729	-	25	-	-
Federated Malay States	[1]61,935	8,057	1,777	9,834	16	225,580	3,555	28	2	170,806	7,000
Unfederated Malay States	[1]2,435	-	-	-	-	-	-	-	-	-	-
Netherland East Indies	36,600	-	-	-	-	-	-	-	-	-	-
Nigeria	9,100	6,658	-	6,658	73	90,553	-	13½	-	13,500	-
Siam	7,900	1,299	-	1,299	16	35,056	-	27	-	40,328	-
Union of South Africa	1,257	-	734	734	58	-	1,783	-	2½	-	-
Others	[3]2,949	-	-	-	-	-	-	-	-	1,343	-
Total	179,000	17,273	26,802	44,075	25	366,795	141,006	21	5¼	237,933	15,050

1 - Exports.

2 - Production included with "others."

3 - Estimated.

CHARACTER OF TIN RESERVES AS RELATED TO METHODS OF MINING

The commercial tin deposits of the world may be divided into two main groups: alluvial, here including residual deposits and tailings, as well as stream deposits; and lode or vein deposits. During 1928 approximately two-thirds of the production came from alluvial deposits and the remaining one-third from lode mines.

The methods of extracting the tin concentrates have an important influence on the data available concerning the reserves. Placer deposits worked by hand-washing methods are seldom tested to prove the reserves because the low cost and portability of equipment make such testing an unnecessary expense. On the other hand, when a tract of alluvium is to be worked by dredging, the cost of erecting the equipment and of preparing the deposit for exploitation is so great that sound business demands a proved reserve which will amortize the initial capital outlay and pay a profit during operation. The useful life of the average dredge is ordinarily placed between 15 and 20 years. It follows that most companies which extract tin concentrates by dredging have data concerning their reserves which usually assure a life of a decade or more from the date of initial production. Between the extremes of extraction by hand-washing and extraction by dredging there are numerous other methods such as hand-jigging, ground-sluicing, small-scale sluicing, gravel-pumping with sluicing, and steam-shovel operations. These methods require varying degrees of initial capital expenditure and ordinarily are undertaken only after enough reserves are proved to amortize the initial capital outlay.

Lode deposit mines in general have smaller proved reserves than placer mines because of the greater expense of blocking out lode ore compared with that of drilling alluvial deposits. Although few tin lode mines have proved reserves which would assure current production for more than four or five years, it may safely be assumed that the tin resources of lode mines taken as a whole are far in excess of any such proved reserves. In fact, it appears most probable that consumers of tin must look to lode mines for their supplies in the not very distant future, much as the consumers of gold look less and less to the rich placers as source of the precious metal.

The course of the tin-mining industry shows a striking resemblance to that of gold mining except that gold mining has advanced much farther in the transition from placer and bonanza lode mining to the large unit treatment of low-grade lode deposits. The great age and depth of the Cornish tin mines which, though productive for centuries, still supply between 1 and 2 per cent of the world's tin, is apt to be paralleled, at least to some degree, by other tin lode deposits of the world.

DISCUSSION OF THE PLACER AND LODE RESERVES OF THE PRINCIPAL TIN-MINING COUNTRIES OF THE WORLD

Federated Malay States

In 1928 the Federated Malay States was the largest producer of tin in the world. The production of 61,935 long tons may be classified as follows: 31,584 tons, or 51 per cent, was derived from Chinese-operated mines; 18,750 tons, or 30 per cent, from European-operated dredges; 8,155 tons, or 14 per cent, from placer operations other than dredging conducted by Europeans; and 3,406 tons, or 5 per cent, from lode mines. For the properties held by Chinese producers, from which more than half the production was derived, no figures of reserves are available. It is probable that a large proportion of this production comes from deposits which have never been tested, as much of the tin is won by methods which require practically no capital for equipment. So far the Chinese have not used dredges but are reported to have made increasing expenditures for other modern equipment. Nothing more than a guess can be made of their reserves, but undoubtedly they are sufficient for some time to come.

Out of a total dredge production of 18,750 tons, 7,866 tons came from properties reporting reserves. These reserves if exploited at the 1928 rate assure a life of 28 years to the group of reporting companies without additional developments or discoveries. Many of the dredging companies not reporting reserves are among the older producers. Some of them are undoubtedly nearly worked out both in respect to ore and serviceability of equipment; but others are developing further reserves, acquiring additional tracts, and prolonging their expectancy more or less indefinitely. In addition to the operating areas there are alluvial tracts already proved to contain over 170,000 tons of tin available at present prices. Most of this proved ground will go into production within a year or two unless new factors arise to stop developments now in progress. Since most of this reserve is to be exploited by dredging it should require at least 20 years to work out and should contribute some 5,000 to 10,000 tons of tin a year in the near future.

There is little available reserve data on the European-controlled placer operations other than dredging, but it is probable that reserves held by such companies afford a shorter expectancy than do the reserves held by dredging companies.

Of the 3,406 tons of tin derived during 1928 from lode mines, 1,777 tons came from mines reporting reserves that assure two years of operation at the 1928 rate. These reserves will undoubtedly be increased as mining and development proceed. Seven thousand tons of tin have been blocked out in lode ore bodies which have not yet been brought into production.

The lack of data on reserves of the Chinese-owned mines makes a forecast of the future production of the Federated Malay States exceedingly difficult. A Government official of the Federated Malay States, though asking not to be directly quoted, made the following statement to Frank L. Hess[4] chief engineer, rare metals and nonmetals division of the United States Bureau of Mines, who has recently returned from a trip through some of the tin-producing areas of Asia: The output of tin in the Federated Malay States probably will gradually rise for the next five years, when it will reach a maximum and remain fairly steady for 20 years longer, after which a decline will begin.

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[4] – The author wishes to acknowledge his indebtedness to Mr. Hess for much of the material contained in the discussion of the Far Eastern areas.

Many of the placer gold regions of the past have become the lode gold regions of the present, and it might be inferred that British Malaya had the prospect of becoming a great lode-tin producing area in the future. The geology of this peninsula, however, does not confirm such an inference. The major part of the tin appears to be derived from extremely low-grade, cassiterite-bearing stock works in schists, granites, and limestones. Only through the agency of placer concentration has the tin content been raised to a mineable grade. Large pieces of cassiterite are so rare that they are exhibited in the museums of Malaya. This apparently precludes the possibility that rich lodes exist, which will take the place of the placer deposits when the production of the latter declines. There also seems to be little likelihood that large undecomposed stockworks of mineable grade will be uncovered.

The British Government has an unusual degree of control over the tin industry in the Federated Malay States and in the Straits Settlements where the concentrates are smelted. It is therefore possible that the tin reserves of this area may be conserved or more rapidly exploited as a result of Governmental action. The recent decision to withhold public mineral lands from private entry and the inauguration of the six-day week in the tin fields indicate a conservation policy on the part of the present Government officials.

Bolivia

During 1928 Bolivia contributed 41,409 tons of tin to world production. Practically all this tin was extracted from lode deposits. Over one-half of the production, or 23,548 tons, came from mines for which reserve figures are available. These reserves assure the mines reporting them an average life of five and a half years at the present rate of production. No nonproducing properties report ore blocked out. Though five and a half years' reserves would amount to very little in alluvial areas, it indicates a very healthy condition when reported for lode deposits. Bolivia's great tin-bearing lodes might well become the backbone of the world's future tin production.

Netherland East Indies

No definite figures are available on the reserves of the Netherland East Indies, though its production of 36,600 tons of tin in 1928 placed it third among world tin producers. The largest producer is the Government, which operates chiefly on the island of Banka. Much of the tin is won by various open-pit methods which do not require the proof of reserves before exploitation. The other two chief producers are the Billiton Co. and the Singkep Co. which operate on islands for which their respective companies are named. Their operations, like those of the Government areas, have required little development of reserves. In 1925 W. R. Jones[5] said:

> The Committee, for example, which recently investigated the tin resources of Billiton for the Dutch Government and the Billiton

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5 - Jones W R , Tinfields of the World London 1925, p 231.

> Company, reported that the proved areas of the island were sufficient to ensure an annual output of from . . . . . 7,000 to 8,000 tons, for a period of 10 years only; and it is within the knowledge of the author, who has visited Billiton, that extensive prospecting all over the island has not resulted in the discovery of important additional areas. The extent and depth of secondary stanniferous deposits can be closely estimated by boring, as has been done in the Dutch East Indies, and it is an interesting and very significant fact that 10 or 12 years hence the bulk of the rich secondary deposits of the Dutch East Indies, of Siam, and of Lower Burma will have been exhausted.

The improvement of mining methods and the possible development of lode deposits in the Netherland East Indies may prolong the life of this area well beyond the 10 or 12 years of the high-grade alluvial areas. Whether production can be maintained at the present level and at near present costs only the future can tell.

Nigeria

Nigeria produced 9,100 tons of tin during 1928, almost wholly from alluvial deposits. Over two-thirds of this production, or 6,658 tons, came from mines which reported their reserves. The reserves as reported afford their companies an average life of 13½ years at the 1928 rate of production. Companies not yet among the producers reported reserves of 9,450 tons of tin. Most of the companies reporting reserves also reported large mining areas as yet untested and, in addition, prospecting rights over much larger areas. It seems reasonable to suppose that Nigeria will greatly extend the life of its tin production as development is carried forward.

Siam

Siam produced 7,900 tons of tin in 1928, of which 1,299 tons came from operations reporting reserves. These reserves were sufficient to assure their owners of production at the present rate for 27 years. The reserves of nonproducers stood at the high figure of 40,328 tons, which would indicate a future expansion for Siam. The production of Siam is practically all from alluvial deposits, and most of the nonproducing reserves either have dredges under construction or are endeavoring to finance dredge operations.

China

China is estimated to have produced 7,033 tons of tin during 1928. Though there are no reserve figures available for the Chinese deposits, the fact that much of the production comes from lodes and residual material at the outcrops of lodes, leads to the belief that China's production of tin should increase rather than decrease for many years to come.

Australia

During 1928 Australia produced 2,900 tons of tin, 211 tons of which came from mines reporting reserves. The reserves of these producers assured an average life of 12½ years at the present rate of production. Nonproducers reported reserves of 7,000 tons of tin. The tin producing areas of Australia are widely scattered and include both lode and placer deposits. There are great reserves of very low-grade disseminated tin ore which should become available with an advance in mining methods or an increase in the price of tin. Australia's reserves appear to be very large but under present mining and price conditions are only on the border line of availability.

United Kingdom

During 1928 the United Kingdom produced 2,782 tons of tin, of which 595 tons came from mines reporting reserves assuring a life of three years; Nonproducing properties reported reserves of 1,050 tons of tin. All production was from the tin-bearing region lying chiefly in Cornwall, which is a striking example of the persistence of tin production in areas depending on lode deposits. An important part of the 1928 production came from lodes whose discovery probably antedates the Christian era. Though only three years' supply of ore is blocked out, it is not at all improbable that this famed tin-yielding area will continue to produce important amounts for many years to come.

India

The province of Burma, India, produced 2,200 tons of tin during 1928. Of this production 1,048 tons came from properties reporting reserves. These reserves were great enough to assure their holders their present rate of production for 16½ years without further development. Properties not yet in production reported reserves of 8,192 tons. Practically all production is won from alluvial deposits located on or near the coast and near the southern extremity of the province.

Union of South Africa

During 1928 the Union of South Africa produced 1,257 tons of tin. Of this amount 764 tons came from mines reporting reserves sufficient for two and a half years' production at the 1928 rate. Most of the tin comes from lode mines, and it seems probable that further development of the Union will bring to light large unknown reserves and probably will not only prolong the period of production but also increase the average annual output.

Other Tin-Producing Countries

The Unfederated Malay States produced 2,435 tons in 1928, the Belgian Congo, 1,200 tons, and all other countries 2,949 tons; no reserve figures are available for their producing properties, but their nonproducers report a total of 8,011 tons of metallic tin in ore blocked out. Some of the countries included under this classification are new in the field of tin production, and it therefore seems probable that their total reserves when proved will be of considerable size in comparison with their present production.

Conclusions

One quarter of the tin production of the world is extracted by companies which report their tin-ore reserves. It is probable that the producing companies which do not report reserves are not generally as well backed by reserves as are the reserve-reporting companies. It is true, however, that many of those not reporting reserves refrain from reporting because of a policy of business secrecy rather than from a desire to conceal an unfavorable state of affairs. This would apply particularly to such producers as the Dutch Government on the island of Banka, which produced 21,000 tons of tin, or 12 per cent of the world total, in 1928. There are some facts that stand out fairly clearly as regards tin reserves: The tin famine which has been predicted as imminent for the last few years undoubtedly has been postponed for some years by the flood of new capital which has entered the tin-mining industry during the recent years of high tin prices; all the important alluvial areas are increasing their outputs with each succeeding year; Bolivia, the greatest lode producer, is increasing its production by further development, better technology, and improved transportation; and the other lode producers, taken as a whole, are holding their own.

Fortunately for those who will consume tin in the future, the major tin-producing areas have been protected from excessive exploitation in the past by their location in the relatively less advanced and naturally more unfavorable regions of the world. The areas centering about British Malaya and including the Federated Malay States, Unfederated Malay States, the Netherland East Indies, Siam, and Burma, though well situated for cheap water transportation, are practically on the equator, in a region whose surface is heavily masked by dense tropical vegetation and peopled largely by industrially backward races. Both prospecting and development has progressed only by overcoming great difficulties in comparison with those encountered in producing most metals in Europe and the United States.

Bolivia, the second greatest tin area of the world, has been greatly handicapped by great altitude, rugged topography, lack of cheap local power, and very expensive transportation. The tin-bearing region of Nigeria has the difficulties attending the inland tropics (10°N); inadequate local power and transportation have made mining difficult. The other areas, which as a whole have about average conditions for mineral production, together produced less than 10 per cent of the world's total tin in 1928.

Fortunate also for future consumers of tin is the fact that many of the uses of tin are not destructive, or are only partly destructive. During 1928 about one-third of the United States' consumption was supplied by domestic secondary tin. Tin entering the alloys is largely recovered to be reused in new shapes after remelting. Practically all tin entering the pigment and silk trades is completely lost when the article containing the tin is finally discarded. That used in the manufacture of tin plate, though at present largely lost, is subject to partial recovery as soon as prices warrant the collection and treatment of discarded tin cans. At present, most of the tin plate clippings, resulting from can manufacture, yield their tin coating for further use.

The reserves of tin appear to be sufficient to supply the world's tin requirements for many years, provided these reserves are exploited and used with care, every effort is made to stimulate substitution when economically possible, and recovery of secondary tin is carried on with care and thoroughness.